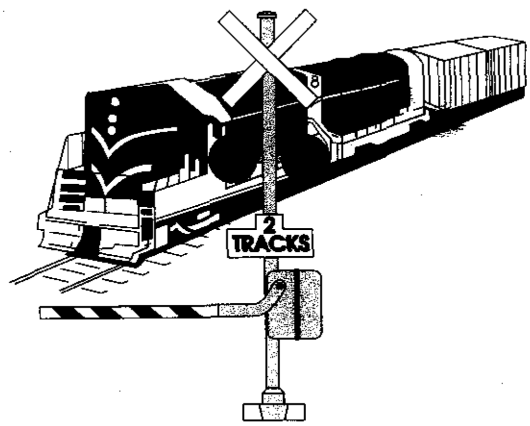
# Evaluation of the Automated Wayside Horn System in Mundelein, Illinois Final Report




Northwestern University Center for Public Safety
405 Church Street

Evanston, IL
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## Executive Summary

### Highway-Rail Crossing Safety and Train Horns

At highway-rail grade crossings, the train horn serves to warn motorists of a train's immediate approach. The horn advises motorists, and other crossing users such as bicyclists and pedestrians, that entering on or crossing the tracks would place them in imminent danger. However, because of the loudness and the wide angle of sound radiation, the horn can be an intrusive nuisance, especially in residential areas near the tracks. As a result, an automated wayside horn system (AWHS) has been developed to provide an appropriate warning for those using the crossing, while not annoying those living near the tracks.

A study was carried out in Mundelein, Illinois, that compared the train horn with the AWHS. This report compares motorists' driving behavior at highway-rail crossings and the sound levels of the two types of horns. The results from the evaluation show a significant 70% decrease in violations of highway-rail crossing law with the AWHS. Noise levels in areas near the tracks decreased by up to 85%.

Reducing the number of collisions between vehicles and trains has remained a priority in highway safety. During the past 10 years, collisions nationally have decreased from 4,684 in 1992 to 3,064 in 2001 (Federal Railroad Administration). During this same period, all collisions with trains in Illinois remained fairly constant with an average of 232 per year. Even though there has been a general decrease nationally, these collisions remain the most severe type in terms of producing injuries and fatalities. Crossing gates have the best record at reducing collisions, but a study done in Florida showed that even with crossing gates, a train horn still is needed. The Federal Railroad Administration (FRA) has proposed rules to require that horns be used at all crossings with few exceptions that are expensive to implement. The problem remains that the train horn, which, in Mundelein, starts sounding approximately 17 seconds before the train reaches the crossing, creates very high sound levels in adjoining areas.

As a result of the need to alert motorists and at the same time reduce the effect of sound on adjoining areas, Mundelein experimented with the use of the AWHS. The study reports the results of the evaluation of the AWHS.

**Conduct of the Study**

Five tasks were undertaken: site preparation, before and after motorist violation studies, before and after sound studies, quality-of-life studies, and surveys of engineers and residents.

At each of the three sites used for studying motorist behavior, utility poles were erected, and cameras and recording equipment installed. The recorders activated when the warning signals activated, thereby recording what motorists did during the period the gates were descending and down before the train arrived.

Drivers are considered to be taking risks (and violating the law) when they attempt to cross the tracks after the crossing gates start to descend. This action was measured by viewing videotapes made at each crossing during the period the gates were activated. Data were taken during the period train horns were in use, then after a period of adaptation, when the wayside horn was in use. The violations were divided into two classes:

Technical violation where the driver crosses the tracks after the gates start to descend but before the gate has been lowered sufficiently to block the vehicle's passage, labeled a "Type 1" violation, and

Deliberate violation in which the driver either drives through or around the lowered gate. These are "Type 2" violations.

Loudness and sound characteristics were measured on approaches to several crossings with train horns in use and then after the wayside horns were activated. A comprehensive assessment of these measures is contained in a separate report; this final report just summarizes the findings.

Measures of quality-of-life derived from two sources: sound studies in residential yards and a survey of the residents. The project team measured sound levels over 24-hour periods at nine locations throughout Mundelein. These measures were made during the period when train horns were used and again after the wayside horns were placed in service. Comparisons included the average sound level in one-second periods, during the time that horns were sounded, and a sound exposure level. The latter takes into account duration and allows direct comparison of sounds between different locations and over different periods.

In addition, surveys were sent to a sample of residents in Mundelein. The survey asked residents how they viewed the new horn system compared to the train horns. Several questions also were directed toward the residents' views of changes in crossing safety.

Finally, a survey was distributed to engineers from both the freight railroad (Canadian National) and commuter rail (Metra). This survey was modeled after the one used in Ames, Iowa, for a similar evaluation. It asked the engineers how they perceived the crossing safety before and after the wayside horns were activated.

**Evaluation of Changes in Crossing Violations**

From the period September 8 through December 20, 2001, 10,392 gate activations were recorded on videotape at three crossings. During the second period of observations, April 12 through July 16, 2002, 9,112 activations were recorded. Each period averaged 36 closings per day or 3.5 per 1,000 crossing vehicles. The largest percentage of closings, 17%, occurred from 6:00 p.m. through 9:00 p.m.

A total of 367 violations were counted during the period when train horns were in use. Only 97 violations were recorded once the wayside horns were in operation. The average violation rate when train horns were in use was 3.53 per 100 gate closings. This decreased 68% to 1.12 per 100 closings with the AWHS. The decrease is statistically significant. Type 1 violations (driving under a descending gate) occurred 358 times in the before period and 93 in the after period. A combined total of 13 drivers in both periods went around a gate. With few exceptions, most of the Type 1 violations occurred within the first two seconds after the gates began their descent.

Of the Type 1 violations recorded when train horns were in use, more than 90% occurred between 6:01 a.m. and 9:00 p.m. Between 12:01 and 3:00 p.m., 30% of all violations occurred. The largest percentage occurred on Hawley Street. Part of the problem stems from multiple gate activations when Metra commuter trains stop at the Mundelein station near Hawley Street.

A total of 13 instances were recorded where motorists drove around the gates. Nine occurred during the time the train horn was in use, and four occurred when the AWHS was operating. The decrease is not statistically significant. Approximately one-half of the violations happened when a train arrived during the 60-second recording interval. In one case, a driver cleared the tracks just 6 seconds before a freight train arrived. On the average, 17 seconds separated the vehicle from the train. At 50 mph, a train would just have passed the whistle post; therefore, the motorist driving around the gates generally might not yet have heard a train horn if train horns were being used. As with Type 1 violations, a large percentage of Type 2 violations occurred in conjunction with Metra commuter operations.

One problem uncovered with the gate operations was gate closure without a train present. Often, this is referred to as a "false activation." These activations comprised approximately 13% of all closings. Metra stops at the Mundelein station and switching operations accounted for a majority of these activations.

Finally, an unusual situation was videotaped during the spring of 2002 in which drivers stopped on the tracks in an apparent response to the wayside horn sounding without prior warning. This happened on 12 occasions. When the drivers went forward, they generally cleared the tracks after the gates had closed just behind them. In other words, in most cases, the drivers occupied the tracks for 12 or more seconds. In one case, a driver backed up, just clearing the descending gate.

### Survey of Residents and Engineers

Two sets of surveys were distributed to examine opinions of both the wayside horn and its perceived safety effectiveness. The respective surveys were administered to more than 1,250 Mundelein residents and to railroad engineers for both the Canadian National Railroad and Metra Commuter Rail.

Residential survey. The 229 residents who responded to the residential survey, by a substantial majority, found the wayside horn much less annoying than the train horns. The exception was persons who lived close to and in a direct line with the wayside horn. More than 15% of respondents found the wayside horn annoying, and a slightly greater percentage responded that "occasionally" the horns interfered with their activities. When compared to the train horn, 88% found the wayside horns either less loud or not even noticeable. A similar percentage also found them less annoying.

When asked about safety, approximately 9% suggested that they were less safe. The same percentage believed that motorists would be more likely to violate crossing laws. On the other hand, the remainder of the respondents believed that the crossings were as safe or safer with the wayside horn than they had been with train horns.

Engineer survey. Both Metra and Canadian National engineers also responded to surveys. One Canadian National and one Metra engineer believed that the crossing was less safe. Neither gave a reason for selecting that answer. However, both also did not like the method of notifying the engineer when the horns were not working. The remaining engineers believed the crossings to be as safe as or safer than when they used the train horn.

### Analysis of the Sounds from Train and Wayside Horns

The key element of the evaluation addressed the differences between the train horn and the wayside horn as it might affect safety of the highway-rail crossing. For the village residents, it was of equal importance to compare how the two horns affected their lives. The findings are discussed in greater detail in a separate report produced as part of the project.

In terms of outcomes, the sound level of the wayside horn was equal to or exceeded that of the train horn for a driver approaching a highway-rail crossing. The exception was when the train reached the crossing, where the train horn was louder. This finding held for a motorist approaching the crossing, whether at the last point where the motorist could stop safely or at the sign warning the motorist of the approaching crossing. The two horns had similar frequency components and were of equal loudness at different frequencies. Perhaps the greatest difference was that the wayside horn is produced electronically and the train horn by air passing through tuned horns. As a result, the sound of the wayside horn had a certain artificiality.

The wayside horn had a significant impact on the quality-of-life in areas near the crossings. At the highest decibel levels, the wayside horn covered 85% less land area than the train-mounted horns. Even at lower levels, more than 65% less area was affected. The residential survey clearly bore out the findings from sound measurements. On the other hand, some persons were affected more than before. Some of this occurred because the pattern of the sound dispersion changed. Volume levels were elongated along the roadway so that some persons heard a louder horn than before. More importantly, because the horns were of constant volume and lasted longer than the train horn, this increased their apparent loudness.

**Summary and Other Issues**

This evaluation of the automated wayside horn system (AWHS) compared the new system to the train horn. It examined three elements for differences:

1. Motorist violations of the law governing gated highway-rail crossings along with perceptions of its safety from drivers and railroad train engineers.

2. The nature of the sound heard by the motorist and the potential effects of any differences on safety at the highway-rail crossing.

3. Quality-of-life for residents as measured both by sound levels, and how the residents perceived the loudness and annoyance of the two warning devices.

With the introduction of the AWHS, motorists' violations of the crossing gates decreased 68%. This difference had less than a 0.0001 likelihood of occurring by chance. The largest change came from Type 1 violations or driving under the closing gates. Because so few motorists drove around the gates during the period the train horns were in use, the decreases occurring during the after period could not be said to be statistically significant. In responses to the surveys, both engineers and residents indicated that they believed the wayside horn created a safer crossing environment for motorists. Because there were no other known changes to the operation of the roadways, the wayside horn is the most likely factor in the reduction of violations.

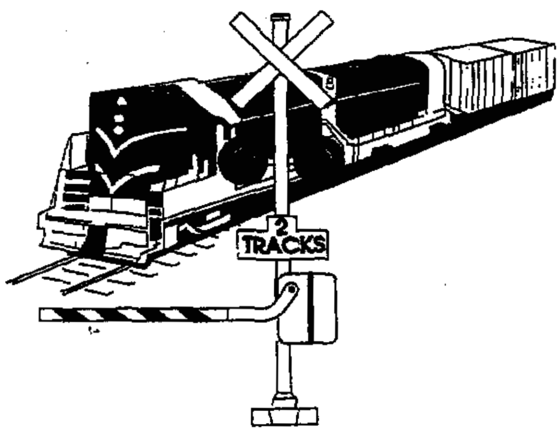
The sound studies showed that, in terms of nature and quality of sound, what the motorist heard from the wayside horn was generally no different from what he or she heard from the train horn. However, there were two differences in sound delivery. The first was that the train horn provides a sense of movement because it gradually increases in volume. The wayside horn starts and remains at a constant volume. The second difference was that the wayside horn sounds when the crossing warning lights first activate while the train horn is usually not heard until the gates are fully descended.

Residential quality-of-life, as measured by the noise levels in the crossing areas, improved significantly with the AWHS. At all levels, from 70 to 90 decibels, the reductions in area covered by a given decibel level, ranged between 65% and 85%. When residents living near the crossings were surveyed about the wayside horns as compared to the train horns, more than 80% of the respondents indicated that their quality-of-life had improved.

Finally, in referring to Type 2 violations (driving around the closed gates), none occurred at Allanson Road. At this crossing, there is a 6-inch raised concrete median that extends approximately 40 feet back from the tracks. While this does not quite meet the proposed FRA standards, it appears to have been sufficient in preventing drivers from going around the gates. Except for the two drivers on Maple who drove around the queue waiting for malfunctioning gates, all of the drivers who went around the gates were the first vehicles in line. Restricting the driver's ability to pull out around the gates for between 30 and 40 feet back from the gate, along with the presence of the wayside horn, probably would eliminate almost all Type 2 violations.

The conclusion then drawn from this study is that the wayside horn significantly reduces highway-rail crossing violations. It accomplishes this task while improving the quality-of-life for nearby residents.

# Comparison of Train and Wayside Horns in Mundelein, Illinois: Analysis of Sounds at Highway-Rail Crossings and in Residential Neighborhoods

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## Executive Summary

### Introduction

Railroad train horns appear to improve safety at highway-rail grade crossings, even ones with crossing gates. However, the loudness of these horns can be a significant nuisance for residents living near the crossings. For this reason, the Village of Mundelein, Illinois, tested the use of an Automated Wayside Horn System (AWHS), which is mounted at the crossings and directs the horn sound down the roadway. The purpose is to alert the motorist of an approaching train while reducing the noise directed toward residential areas.

Current Federal Railroad Administration (FRA) rules require that railroad train horns be capable of generating 96 decibels (dB) at 100 feet (30.5 meters) in the forward direction of the train. While the horns are aligned with the direction of train travel, directivity plots of sound levels show that these sounds radiate with minimal decrease up to 60 degrees to each side. This would mean that persons residing away from the railroad would be subject to approximately the same sound volume as those near the tracks.

The analysis of sound levels and acoustical characteristics heard by motorists show minimal differences between the railroad horn and the wayside horn. Motorists approaching the crossing when the gates are being lowered are more likely to hear the wayside horn because it is much louder than the approaching train's horn. Once the motorist is at the gate, the train horn becomes louder than the wayside horn only when the train is within a few seconds of reaching the crossing.

Frequency and temporal characteristics of both horns are similar, with patterns over the normal ranges for hearing. Finally, residential areas experienced a significant reduction in sound levels once the wayside horns were introduced. In many cases, the wayside horn could not be distinguished from background noises.

### Brief Introduction to Measuring Sound

Sound and noise often are used interchangeably to describe a sensation that can be detected by the ear. However, the study of sound (acoustics) often distinguishes between noise as "unwanted sound" and sound as an "auditory sensation produced through the ear by alteration in pressure..."

Sound travels through most media, e.g. air, water, and metal, as a wave that has both amplitude defining loudness, and a cycle length that defines frequency.

Amplitude is the "strength" of a sound wave, and it represents loudness. It is measured as sound pressure. The common measure is decibels and it is known as the sound pressure level (SPL).

When comparing similar sounds, a useful set of relationships can be employed in describing the change in loudness of a sound. These are: a 3 dB increase represents a just noticeable difference, a 5 dB change is considered a significant increase, and a 10 dB change represents a doubling of loudness.

Sound also is described by the number of oscillations or cycles per second (notated as Hertz – Hz); this is the frequency. Although the frequency range of hearing is considered to be 20-20,000 Hz, the ear is not equally sensitive to all these frequencies. Frequencies from 1,000 to 4,000 Hz are heard best.

The length of time the sound is heard makes a difference in how the listener perceives the sound. A very loud sound with a very short duration, e.g., a gunshot, may not be as noticeable as a sound with a lower decibel reading but heard over a longer period.

For this study sound was measured using digital audio tape and an "integrating sound level meter." This device captures the sound in a manner similar to how the human hears. It calculates the sound pressure levels over various periods, usually one second, weights the reading, and stores the weighted result for each period.

While the integrating sound level meter can produce many metrics, two are commonly displayed: the "equivalent continuous sound level" denoted by $L_{eq}$ and the maximum sound level, $L_{Max}$. The $L_{eq}$ is the constant level of sound, in dB, that contains the same *energy* as the actual fluctuating noise over a stated time interval. The maximum SPL (denoted by $L_{max}$) is a metric used to capture the greatest noise level observed over the sampling period. Various levels are used to describe the sound heard over a given period, but the two most common are $L_{90}$ – the level exceeded 90% of the time (often referred to a the background or ambient level) and $L_{10}$ – the level exceeded 10% of the time (or intrusive noise levels).

Finally, the exposure level (SEL) is an energy average of noise over a certain time interval (like the $L_{eq}$), but it is normalized to one second. For example, a one-hour $L_{eq}$ is found by averaging the one-second $L_{eq}$'s for the period, where as the SEL for that period is a summing of the same one-second $L_{eq}$'s. Because of its normalization the SEL is useful for comparing the effect of events with different maximum levels and durations.

**Acoustical Comparison of Train vs. Wayside Horns**

This is a comparison of the acoustical parameters of sound generated by conventional train-mounted horns with the wayside pole-mounted horns. To assess the sound levels generated by train-mounted horns vs. wayside horns, sound level data were collected by digital recordings. Two locations within the Village of Mundelein, Illinois, were selected for the recording sites. The Hawley Street crossing was selected because of its location downtown near reflective buildings and residential properties. The second site at the Winchester Road crossing was selected because of its location away from reflective buildings and is also more distant from residential properties.

Two monitoring stations were used; one at 110 feet from the centerline of the crossing and the second location at 300 feet. These represented two different points at which motorists would be expected to respond to train or wayside horns. Data sampling for the locomotive horns were made on in December 2001. The sapling for the wayside horns occurred late May/early June 2002.

Train-mounted horns are typically multi-tone, air-driven devices intended to emit a high sound intensity level. Each horn produces a different fundamental frequency (pitch). Usually, these sounds are dissonant meaning that the fundamental frequencies are not musically aligned. This dissonance adds to its alerting function. The wayside horn sound was created from a digital recording of a typical train horn. As such, few differences between the harmonic structures of the two types of horns were expected. However, there are other acoustical characteristics of a train horn that make it different from a wayside horn. This includes a ramp effect - the increase in amplitude as the train approaches, the Doppler Effect - a slight upward shift in frequency as the train approaches the crossing, and interference effects - the fluctuation in amplitude as the sound arrives at the listener by various direct and reflective paths that provide constructive and destructive interference.

It was not the purpose of this study to perform an exhaustive analysis of train and wayside horns. However, it was important to verify that the spectral energy in both cases is similar. These data confirm that, although the angle of incidence is a factor, because the amplitude and frequency content of the two types of horns are similar, the audibility inside a vehicle should also be similar. In other words, the sound transmission loss provided by a vehicle to diminish the intensity of the wayside horn would have the same effect on a train horn signal as well.

Train horns typically produce A-weighted sound levels of about 105 dB(A) at 100 feet. The typical horn is a blast of "long-long-short-long." For the second and third long blasts (when the train is close to or at the crossing) the average SPL was 92 and 103 dB(A), respectively. The 2nd blast is lower simply because of a greater distance to the recording station. The blasts from the wayside horn were uniform. Each ranged from approximately 94 to 97 decibels. The single greatest difference was that the loudness of the train horn increased as the train approached. The wayside horn was constant.

The sound levels at 300 feet from the crossing approximated those at 110 feet. Both horns were slightly lower in volume because of the added distance from the source. Variability of the train horns was greater at this distance because of the opportunity for more factors to influence the sound levels.

One major difference between the two horns was duration. While the sequences from the train and wayside horn were each approximately 17 seconds, the wayside horn sounded over two or more complete sequences, some as long as 45 seconds. These findings are important if the purpose of the wayside horn is to match the purpose of the train horn. In other words, it may be insufficient to simply reproduce the static amplitude, frequency, and duration of a train horn blast. Of importance may also be mimicking the dynamic features of a train horn, which would be to include only one sequence, adjusting the onset of the sequence, and providing an amplitude ramp to avoid startling pedestrians.

**Comparison of Sound Levels in Residential Areas**

To obtain a better understanding of changes in the sound levels in areas near crossings from when the train horn was being used to after the wayside horn began operating, the Northwestern University Center for Public Safety (NUCPS) conducted sound studies in residential yards. The research team used an integrating sound level meter for the recordings. These were taken in one-second intervals over a period of 24 hours for each location. Residents were located between 500 and 1,500 feet from that portion of the tracks where use of a train horn was expected. Sound samples were taken at a set of residences over a two-week period, in the fall of 2001 and again in the spring of 2002.

With availability of videotapes for drivers at crossings near the sampling sites, the arrival of a train could be linked to the actual recordings. For the train horns, their horn patterns were loud enough to present distinct differences in the loudness of the recorded data. This was not the case for wayside horns where many times, their volume was only slightly louder than the background noise.

Although the readings were taken a varying distances from the tracks and subject to varying levels of influence on their loudness (buildings, vegetation, etc.), when the $L_{eq}$ was converted back to an expected level at 100 feet from the front of the train horn, the resulting adjusted dB readings were very similar. They differed by 6 dB from 99 dB to 105 dB. For the wayside horn, conversion back to the horn was within 3 dB of that level recorded at the selected distance of 110 feet.

A four-hour nighttime block from 8:00 p.m. to midnight was chosen for making comparisons because that is when the horns are most likely to be heard by the residents. The maximum decibel reading with train horns during the four nighttime hours for any location was 84 dB at two locations; the highest SEL was 95 dB. Background levels ($L_{90}$) ranged from 42 dB to 52 dB. The average sound levels of train horns during the four hours ranged between 10 dB and 30 dB above the 10% level, and generally were 30 dB higher than the background level.

The maximum reading of 75 dB for the wayside horn occurred at the Village Hall. It also was the closest location to the wayside horn, as well as directly in line with the direction of the speaker. The lowest maximum reading was 61 dB. On several occasions at a number of locations, the wayside horn could not be distinguished from the background level even when the train was known to be present in part because of the lower level of sound detected at a location and an increase in background noise levels during the spring. With the exception of the Village Hall, all median SEL's decreased. At three locations, the decrease was 3 dB or less; the largest decrease was 27 dB.

Equal contours of loudness were mapped using five contours representing 70, 75, 80, 85, and 90 dB. For example, the 70 dB contour produced by the train horns covered 4.29 square miles ($mi^2$) representing 37% of the 7.79 $mi^2$ computed for the entire village. The 90 dB coverage was 0.36 $mi^2$ or approximately 230 acres. This represented 3.8% of the village area. Because the sound from the train horn radiates fairly constantly over a 180-degree sector, the sound pattern for both directions of travel approximates a slightly flattened circle decreasing by one-half for each 5 dB decrease. Based on the attenuation of sound, a decrease in area by one-half for each 5 dB increase would have been expected.

On the other hand, the wayside horn is very directional with most of the sound energy occurring along the primary speaker axis. Outside that axis, the drop-off in sound is rapid. This is evident in the plot of contours based on sound readings from the wayside horns. The 90 dB reading for the wayside horn cover 0.02 $mi^2$, approximately 14 acres or 93% less area than the train horn. The decrease in area covered at 70 dB was somewhat less.

**Concluding Comments**

Use of the wayside horn, from an analysis of sound, is no different from the train horn. It is of equal loudness and covers the same frequency spectra. Given its directionality, the wayside horn may be more likely to be heard by the motorist and less likely by the residents. For those people living in Mundelein, the wayside horn has generated a significant improvement in quality of life in terms of a substantial reduction of noise pollution.

Train Horns, Wayside Horns, and Motorists. The sound levels at various frequencies from the wayside horn closely match the train horn. While the wayside horn sounds similar to the train horn, the operation of each is different. With few exceptions, motorists approaching a gated highway-rail crossing always are alerted to the presence of a train prior to when the train horn sounds. The bells, flashing lights, and descending gates serve this function. The train horn normally is not heard until 3 to 5 seconds after the gates fully descend. On the other hand, the motorist approaching a crossing with a wayside horn immediately hears the horn when the signals activate.

One problem is that because the wayside horns sounds at the same time the signals start to operate, the motorist has no warning for the loud noise. As a result, the wayside horn has startled and confused people. On at least 12 occasions, motorists stopped on the tracks and proceeded only after the gates had begun to descend.

Residential Sound. Implementation of wayside horns has made a significant difference in the residential quality of life from when the train-mounted horns were used. Some residents who were located several hundred feet from the tracks were hearing sounds above 90 decibels (similar to a jackhammer at 5 feet) at all times of day and night. Because of the relatively low background noise level, the train horns were of the magnitude of 8 to 16 times louder than the background. Moreover, the loud sounds were not limited to a relatively small area. The 85 dB curve, for example, covered approximately 0.71 square miles of the village.

Once the wayside horns were installed, sound coverage, especially at higher volumes, decreased by a factor of 10. Those benefiting the most lived at angles of 45° or more from the wayside horn. The problem that has arisen, of course, is that not everyone benefited. In a few cases, the volume recorded actually has increased. More importantly for a larger number of persons the sound exposure level also has remained approximately constant, or, perhaps, even increased. If the wayside horn more closely mimicked the train horn, this would reduce the length of its use as well as gradually increasing in volume.

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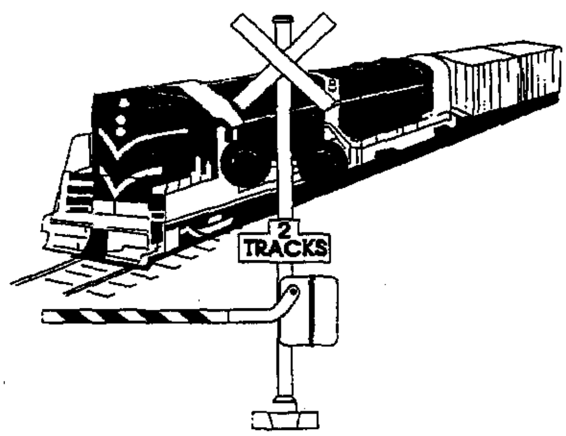


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**Evaluation of Changes in Crossing Violations**

From the period September 8 through December 20, 2001, 10,392 gate activations were recorded on videotape at three crossings. During the second period of observations, April 12 through July 16, 2002, 9,112 activations were recorded. Each period averaged 36 closings per day or 3.5 per 1,000 crossing vehicles. The largest percentage of closings, 17%, occurred from 6:00 p.m. through 9:00 p.m.

A total of 367 violations were counted during the period when train horns were in use. Only 97 violations were recorded once the wayside horns were in operation. The average violation rate when train horns were in use was 3.53 per 100 gate closings. This decreased 68% to 1.12 per 100 closings with the AWHS. The decrease is statistically significant. Type 1 violations (driving under a descending gate) occurred 358 times in the before period and 93 in the after period. A combined total of 13 drivers in both periods went around a gate. With few exceptions, most of the Type 1 violations occurred within the first two seconds after the gates began their descent.

Of the Type 1 violations recorded when train horns were in use, more than 90% occurred between 6:01 a.m. and 9:00 p.m. Between 12:01 and 3:00 p.m., 30% of all violations occurred. The largest percentage occurred on Hawley Street. Part of the problem stems from multiple gate activations when Metra commuter trains stop at the Mundelein station near Hawley St.

A total of thirteen instances were recorded where motorists drove around the gates. Nine occurred during the time the train horn was in use, and four occurred when the AWHS was operating. The decrease is not statistically significant. Approximately one-half the violations happened when a train arrived during the 60-second recording interval. In one case, a driver cleared the tracks just 6 seconds before a freight train arrived. On the average, 17 seconds separated the vehicle from the train. At 50 mph, a train would just have passed the whistle post; therefore, the motorist driving around the gates generally might not yet have heard a train horn if train horns were being used. As with Type 1 violations, a large percentage of Type 2 violations occurred in conjunction with Metra commuter operations.

One problem uncovered with the gate operations was gate closure without a train present. Often, this is referred to as a "false activation." These activations comprised approximately 13% of all closings. Metra stops at the Mundelein station and switching operations accounted for a majority of these activations.

Finally, an unusual situation was videotaped during the spring of 2002 in which drivers stopped on the tracks in an apparent response to the wayside horn sounding without prior warning. This happened on 12 occasions. When the drivers went forward, they generally cleared the tracks after the gates had closed just behind them. In other words, in most cases, the drivers occupied the tracks for 12 or more seconds. In one case, a driver backed up, just clearing the descending gate.

**Survey of Residents and Engineers**

Two sets of surveys were distributed to examine opinions of both the wayside horn and its perceived safety effectiveness. The respective surveys were administered to more than 1,250 Mundelein residents and to railroad engineers for both the Canadian National Railroad and Metra Commuter Rail.

Residential survey. The 229 residents who responded to the residential survey, by a substantial majority, found the wayside horn much less annoying than the train horns. The exception was persons who lived close to and in a direct line with the wayside horn. More than 15% of respondents found the wayside horn annoying, and a slightly greater percentage responded that "occasionally" the horns interfered with their activities. When compared to the train horn, 88% found the wayside horns either less loud or not even noticeable. A similar percentage also found them less annoying.

When asked about safety, approximately 9% suggested that they were less safe. The same percentage believed that motorists would be more likely to violate crossing laws. On the other hand, the remainder of the respondents believed that the crossings were as safe or safer with the wayside horn than they had been with train horns.

Engineer survey. Both Metra and Canadian National engineers also responded to surveys. One Canadian National and one Metra engineer believed that the crossing was less safe. Neither gave a reason for selecting that answer. However, both also did not like the method of notifying the engineer when the horns were not working. The remaining engineers believed the crossings to be as safe as or safer than when they used the train horn.

**Analysis of the Sounds from Train and Wayside Horns**

The key element of the evaluation addressed the differences between the train horn and the wayside horn as it might affect safety of the highway-rail crossing. For the village residents, it was of equal importance to compare how the two horns affected their lives. The findings are discussed in greater detail in a separate report produced as part of the project.

In terms of outcomes, the sound level of the wayside horn was equal to or exceeded that of the train horn for a driver approaching a highway-rail crossing. The exception was when the train reached the crossing, where the train horn was louder. This finding held for a motorist approaching the crossing, whether at the last point where the motorist could stop safely or at the sign warning the motorist of the approaching crossing. The two horns had similar frequency components and were of equal loudness at different frequencies. Perhaps the greatest difference was that the wayside horn is produced electronically and the train horn by air passing through tuned horns. As a result, the sound of the wayside horn had a certain artificiality.

The wayside horn had a significant impact on the quality of life in areas near the crossings. At the highest decibel levels, the wayside horn covered 85% less land area than the train-mounted horns. Even at lower levels, more than 65% less area was affected. The residential survey clearly bore out the findings from sound measurements. On the other hand, some persons were affected more than before. Some of this occurred because the pattern of the sound dispersion changed. Volume levels were elongated along the roadway so that some persons heard a louder horn than before. More importantly, because the horns were of constant volume and lasted longer than the train horn, this increased their apparently noise.

**Summary and Other Issues**

This evaluation of the automated wayside horn system (AWHS) compared the new system to the train horn. It examined three elements for differences:

1. Motorist violations of the law governing gated highway-rail crossings along with perceptions of its safety from drivers and railroad train engineers.

2. The nature of the sound heard by the motorist and the potential effects of any differences on safety at the highway-rail crossing.

3. Quality of life for residents as measured both by sound levels, and how the residents perceived the loudness and annoyance of the two warning devices.

With the introduction of the AWHS, motorists' violations of the crossing gates decreased 68%. This difference had less than a 0.0001 likelihood of occurring by chance. The largest change came from Type 1 violations or driving under the closing gates. Because so few motorists drove around the gates during the period the train horns were in use, the decreases occurring during the after period could not be said to be statistically significant. In responses to the surveys, both engineers and residents indicated that they believed the wayside horn created a safer crossing environment for motorists. Because there were no other known changes to the operation of the roadways, the wayside horn is the most likely factor in the reduction of violations

The sound studies showed that, in terms of nature and quality of sound, what the motorist heard from the wayside horn was generally no different from what he or she heard from the train horn. However, there were two differences in sound delivery. The first was that the train horn provides a sense of movement because it gradually increases in volume. The wayside horn starts and remains at a constant volume. The second difference was that the wayside horn sounds when the crossing warning lights first activate while the train horn is usually not heard until the gates are fully descended.

Residential quality of life, as measured by the noise levels in the crossing areas, improved significantly with the AWHS. At all levels, from 70 to 90 decibels, the reductions in area covered by a given decibel level, ranged between 65% and 85%. When residents living near the crossings were surveyed about the wayside horns as compared to the train horns, more than 80% of the respondents indicated that their quality of life had improved.

Finally, in referring to Type 2 violations (driving around the closed gates), none occurred at Allanson Road. At this crossing, there is a 6-inch raised concrete median that extends approximately 40 feet back from the tracks. While this does not quite meet the proposed FRA standards, it appears to have been sufficient in preventing drivers from going around the gates. Except for the two drivers on Maple who drove around the queue waiting for malfunctioning gates, all of the drivers who went around the gates were the first vehicles in line. Restricting the driver's ability to pull out around the gates for between 30 and 40 feet back from the gate, along with the presence of the wayside horn, probably would eliminate almost all Type 2 violations.

The conclusion then drawn from this study is that the wayside horn significantly reduces highway-rail crossing violations. It accomplishes this task while improving the quality of life for nearby residents.